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# UK Patent Application

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INT CL<sup>6</sup> H05K 13/00  
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## (54) Circuit board and apparatus for recognizing the position of a circuit board

(57) In a circuit board, a fiducial mark (2) of the same material as that of a circuit pattern is formed on a main surface of a board (1) on which the circuit pattern is formed, and it is coated with a solder resist film (3). According to this circuit board, it is possible to carry out position recognition by irradiating infrared rays without exposing the fiducial mark (2), so that oxidation of the fiducial mark (2) or attachment of solder thereto are prevented. An apparatus for recognizing the position of a circuit board includes means (22) for picking up the image of the surface of a circuit board (20), means (23) for recognizing the position of the circuit board (20) from thus obtained image, and means (21) for irradiating infrared rays toward the circuit board (20).

In another arrangement the apparatus is used to detect the position of part of the wiring pattern rather than a fiducial mark.

FIG.6

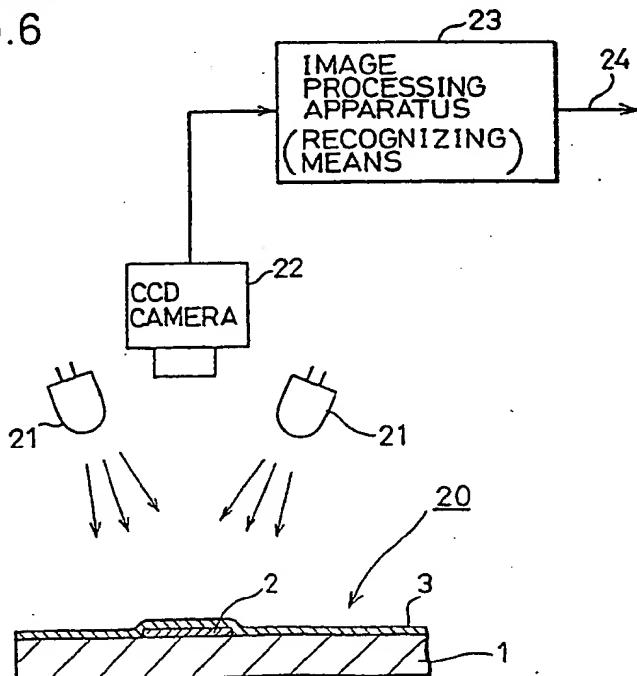


FIG. 1A

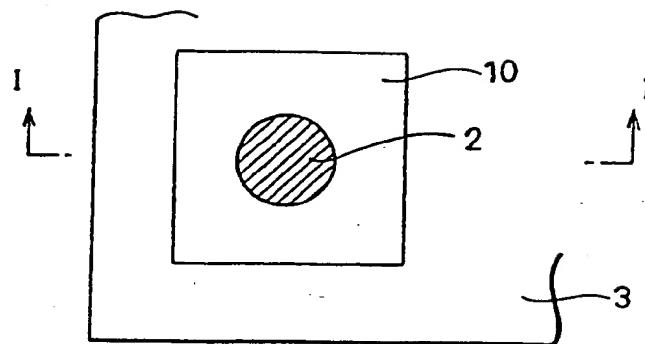


FIG. 1B

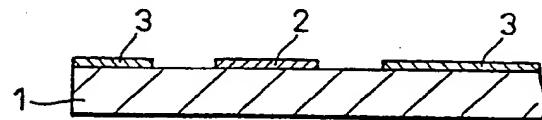


FIG. 3A

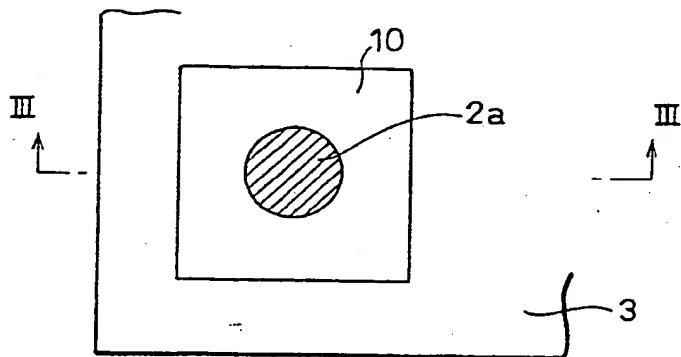


FIG. 3B

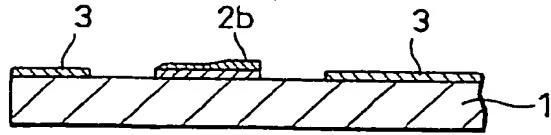


FIG. 2A

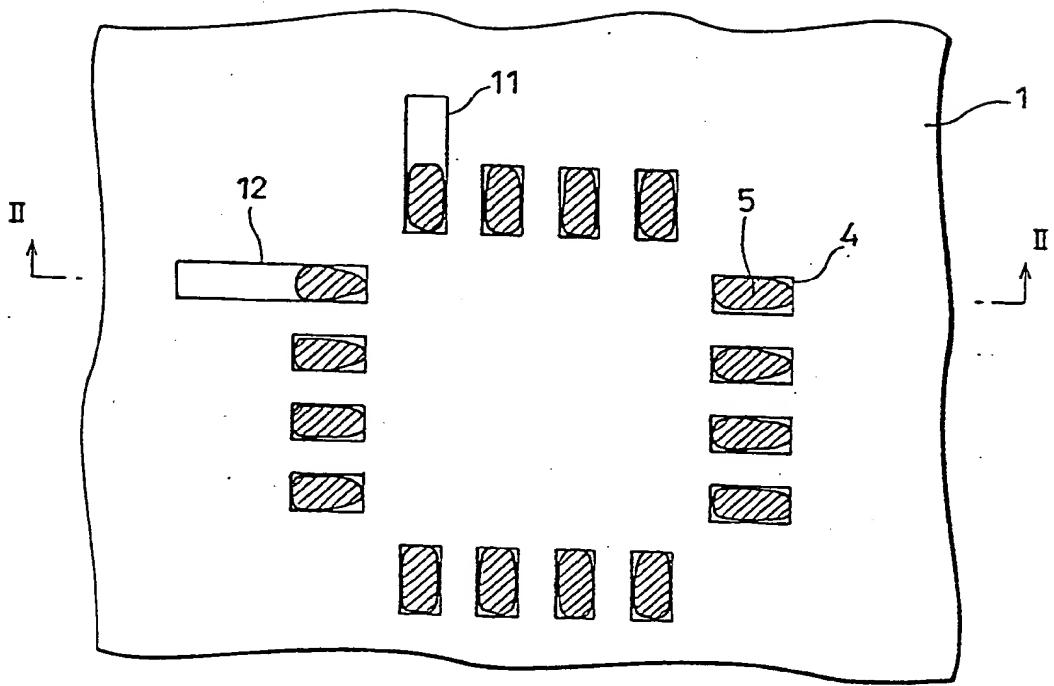


FIG. 2B

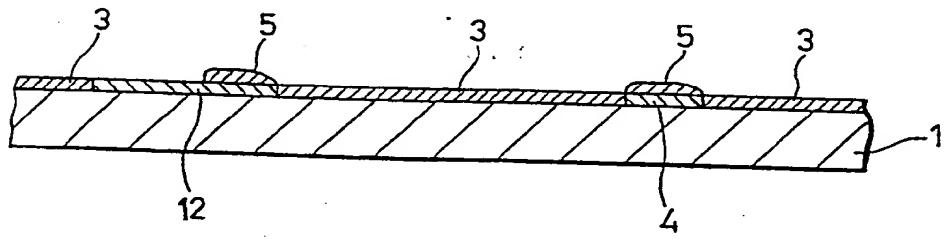


FIG. 4

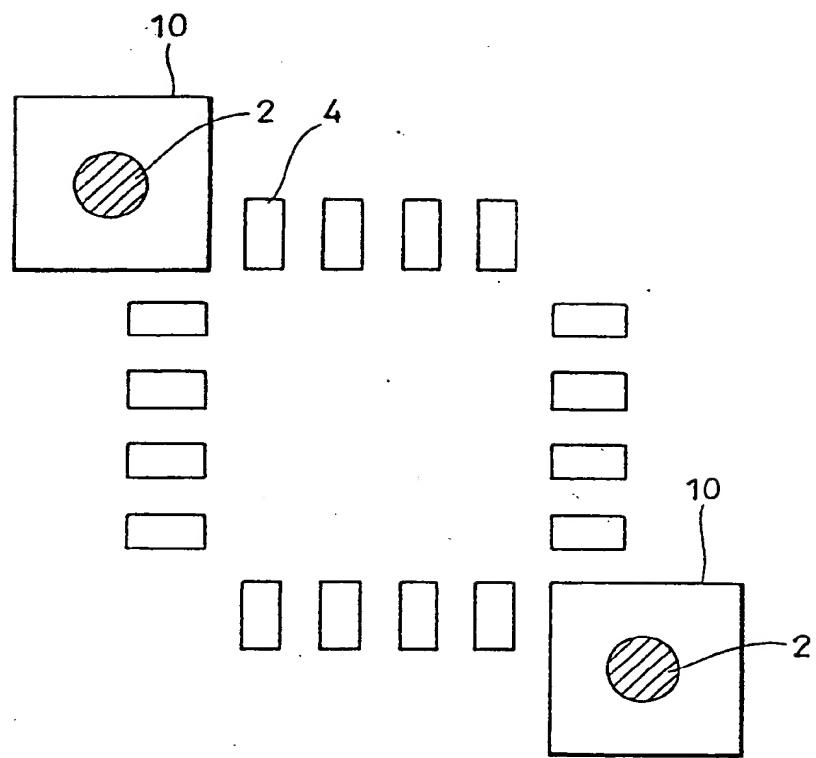


FIG.5A

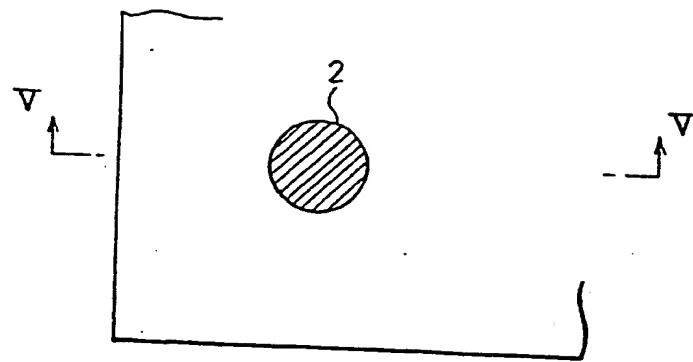


FIG.5B

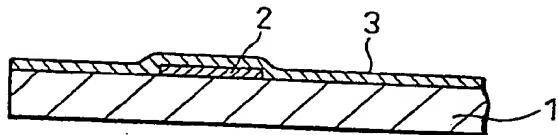


FIG.6

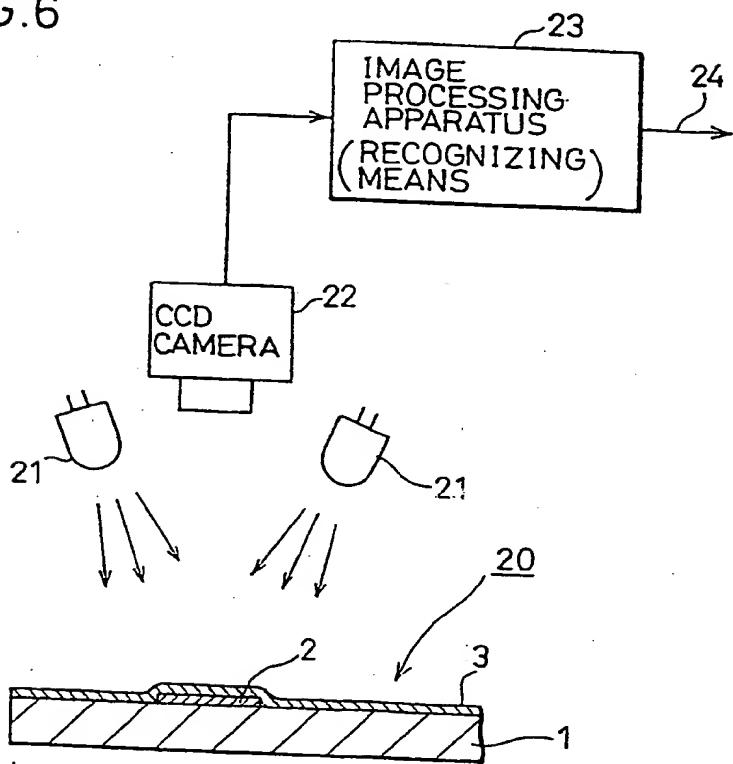


FIG.7

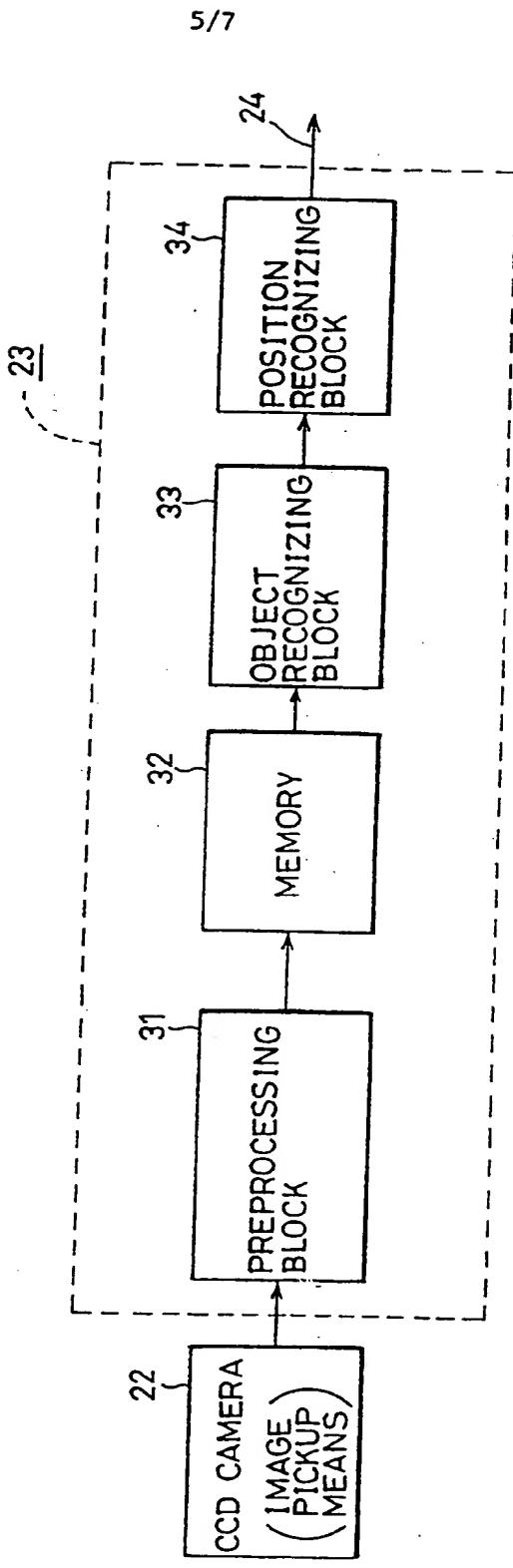


FIG. 8

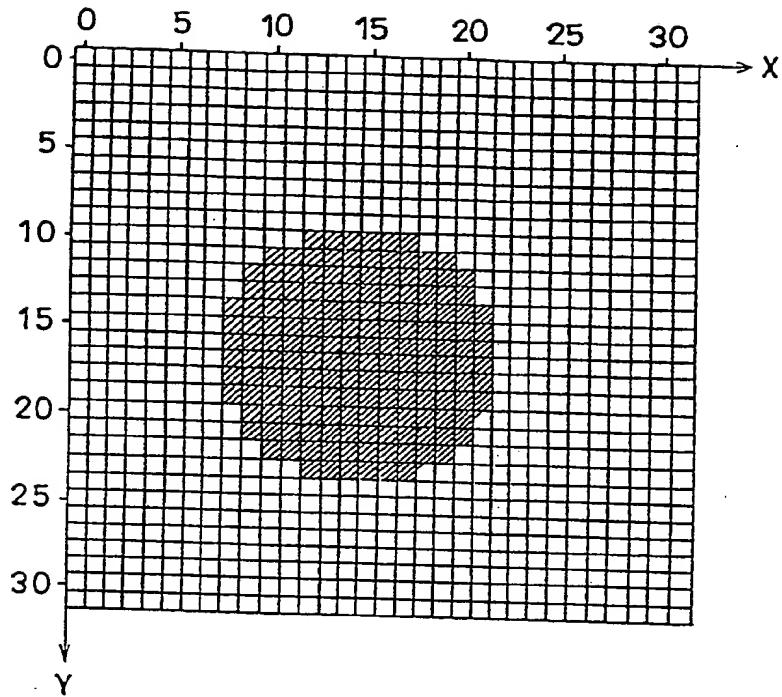
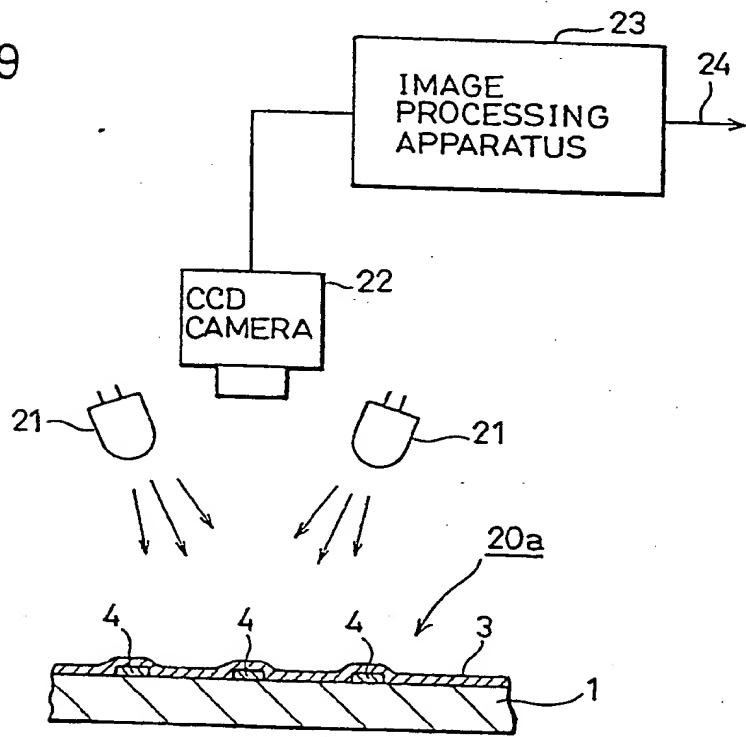


FIG. 9



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FIG.10

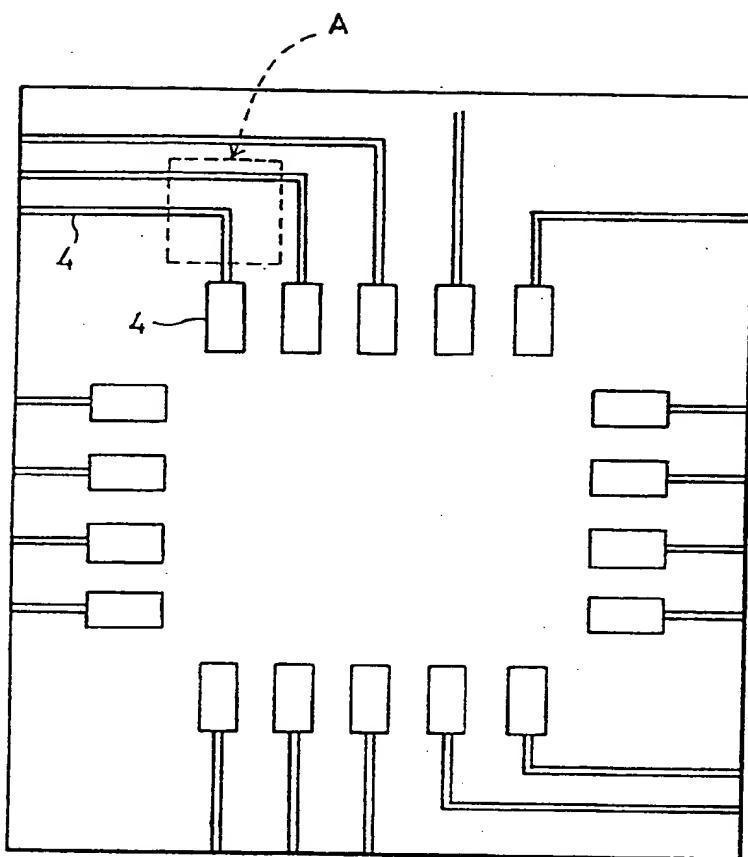
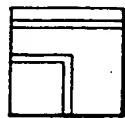


FIG.11



**TITLE OF THE INVENTION**

**Circuit Board and Apparatus for Recognizing the Position of Circuit Board**

**BACKGROUND OF THE INVENTION****5 Field of the Invention**

The present invention relates to a circuit board suitable for positioning a board applied in packaging of electronic parts and package test and an apparatus for recognizing the position of a circuit board.

**10 Description of the Background Art**

In recent years, the packaging density of electronic parts in a circuit board has become high, and it has become impossible to obtain sufficient precision for automatic packaging of parts by a mechanical method of 15 positioning a circuit board with a fiducial hole and a fiducial pin. As a result, a technique for directly positioning a circuit pattern in a position for packaging parts without contact is required.

The above-described position for packaging parts is a 20 position for soldering the parts, and cream solder is applied to that position in a process of surface packaging in which reflow soldering is carried out, so that it is difficult to recognize the circuit pattern in that position with high precision. In the case of a circuit 25 board in which parts are packaged with high density, a

circuit pattern unnecessary in a step of soldering is normally coated with a solder resist film so that solder does not attach thereto. It is not easy to pick up the image of the circuit pattern beneath the solder resist  
5 film, so that it was difficult to recognize with high precision a circuit pattern other than the circuit pattern to be soldered (the circuit pattern coated with the solder resist film). Thus, it was difficult to recognize a circuit pattern whether a circuit pattern to be soldered  
10 is used or a circuit pattern to be soldered is used.

In order to solve this problem, there is an adopted method in which a fiducial mark of a same material as that of a circuit pattern is formed together with the circuit pattern on a board, the fiducial mark is left not coated  
15 with a solder resist film and has the image picked up by a television camera, and then the position of the board is recognized with high precision without contact by a pattern recognizing technique. In the case where this method is adapted, an indispensable condition is that the  
20 fiducial mark is not coated with the solder resist film, and, for example, some specifications of chip parts mounting machines on the market indicate clearly that a fiducial mark should not be provided with a solder resist film.

25 Figs. 1A, 1B illustrate an example of a conventional

fiducial mark formed on a main surface of a board, wherein Fig. 1A is a plan view of it, and Fig. 1B is a sectional view taken along line I-I in Fig. 1A. Referring to Figs. 1A, 1B, a circular fiducial mark 2 is formed using copper foil, which is the same material as that of a circuit pattern, on a main surface of a board 1 formed of glass epoxy or the like. A resist film 3 is also formed on the main surface of board 1, and fiducial mark 2 is positioned in a region 10 where resist film 3 is not formed. Thus formed fiducial mark 2 has the image picked up by a television camera or the like and recognized by a pattern recognition technique, and the position of the circuit board is recognized on the basis of the position of the recognized fiducial mark.

There is another method for solving the above problem, in which a part of a circuit pattern not used in soldering parts is utilized. Specifically, a solder resist film is removed from the part not used in soldering parts to expose that part, and that part has the image picked up by a television camera or the like. That part is recognized from the image obtained by image pickup using a pattern recognition technique, and the position of a circuit board is recognized on the basis of the position of the recognized part. Figs. 2A, 2B illustrate an example of a part of a circuit board whose position is

recognized by this method, wherein Fig. 2A is a plan view  
of it, and Fig. 2B is a sectional view taken along line  
II-II in Fig. 2A. The circuit pattern illustrated in  
Figs. 2A, 2B are for soldering a flat package IC in which  
5 there are lead wires in four directions, and it is  
illustrated in a state where cream solder 5 is applied to  
circuit patterns 4, 11, 12 formed of copper foil. Circuit  
patterns 11, 12 each includes a part not used in soldering  
the IC. This part is not coated with a solder resist film  
10 3 and exposed. Therefore, a television camera or the like  
picks up the image of this part. The positions of circuit  
patterns 11, 12 are recognized from the image obtained by  
image pickup, and the position of the circuit board in a  
longitudinal direction and a lateral direction is  
15 recognized from the recognition result.

Since conventional circuit board and apparatus for  
recognizing the position of a circuit board are  
constituted as described above, fiducial mark 2 on board 1  
is not coated with solder resist film 3 and its material  
20 is exposed, so that there was a problem that there is a  
case where its surface is oxidized and the reflectance  
becomes uneven, and, as a result, the lightness of the  
fiducial mark in the image obtained by a television camera  
or the like becomes uneven, and position recognition with  
25 high precision becomes impossible. In addition, in a case

where the image of the parts of circuit patterns 11, 12  
not coated with solder resist film 3 is picked up to  
recognize the position of the circuit board, there was  
also a case where the surfaces of those parts are oxidized  
5 and the reflectance becomes uneven, and position  
recognition with high precision becomes impossible.

There is also a case where solder plating is carried  
out in the part not coated with solder resist film 3 for  
the purpose of preventing oxidation of circuit patterns 4,  
10 11, 12 and enhancing solderability. In that case, the  
whole circuit board is immersed in a soldering bath, so  
that solder plating is carried out also on fiducial mark 2  
and the whole of circuit patterns 11, 12 not coated with  
solder resist film 3.

15 Figs. 3A, 3B illustrate a state of the one  
illustrated in Figs. 1A, 1B after solder plating is  
carried out. Referring to Figs. 3A, 3B, 2a indicates a  
fiducial mark on which a solder plate 2b is provided. In  
a case where solder plate 2b is provided, although  
20 oxidation of the surface is prevented, the plate surface  
is not smooth, and it shows reflection characteristics  
with high directivity as that of a mirror. Accordingly,  
when the image of that part is picked up by a television  
camera or the like, the lightness of the image also  
25 becomes uneven. The same problem arises also in the case

where solder plating is not carried out on a circuit board if it is soldered by a flow soldering process.

Specifically, the surface of a circuit board is immersed in a soldering bath, so that in a case where positioning

5 of the circuit board is carried out for the purpose of testing deviation of the position of package parts after solder plating, the same problem as the one arising in the case of carrying out solder plating arises. In the case of a circuit board soldered by a reflow soldering process,  
10 it passes a reflow furnace at high temperature, so that oxidation of the surface is caused.

In the case of mounting an IC with a large number of pins in which the space between lead wires is extremely narrow, another problem also arises. Since positioning

15 with particularly high precision is required in this case, it is necessary to carry out position recognition using fiducial mark 2 near the mounting position of the IC or circuit patterns 11, 12. Fig. 4 illustrates an example in which fiducial marks 2 are provided in the vicinity of the  
20 left upper part and right lower part of the mounting position of the IC. In a case where fiducial mark 2 is used, it is necessary to provide fiducial marks 2 corresponding the number of ICs. As a result, there was a problem that a board area unnecessary for implementing an  
25 original circuit function is required, and miniaturization

of a circuit board is prevented. In a case where the pattern has high precision, it is difficult to remove with high precision the solder resist film from circuit patterns 11, 12, so that it is not possible to use circuit 5 patterns 11, 12 instead of fiducial mark 2, either.

#### SUMMARY OF THE INVENTION

A first object of the present invention is to provide a circuit board capable of preventing oxidation of the surface of a fiducial mark formed on the board or 10 attachment of solder thereto.

A second object of the present invention is to provide an apparatus for recognizing the position of a circuit board, which is capable of recognizing with high precision a fiducial mark formed by coating the board with 15 a solder resist film or a circuit pattern formed by coating the board with a solder resist film, and, as a result, recognizing with high precision the position of the circuit board.

A circuit board according to the present invention 20 achieving the above first object includes a fiducial mark of the same material as a circuit pattern formed, with the surface covered with a solder resist film, on a main surface of a board on which the circuit pattern is formed.

According to this circuit board, infrared rays which 25 transmit the solder resist film are irradiated, so that

position recognition can be carried out without exposing the fiducial mark. Therefore, the surface of the fiducial mark is always kept in a stable state without being oxidized or having solder attached thereto, so that it is  
5 possible to carry out detection of the position of the circuit board with high precision. Further, the material of the fiducial mark is the same as that of the circuit pattern, so that it is possible to pattern the fiducial mark at the same time that the circuit pattern is formed.

10 According to a preferred embodiment of a circuit board of the present invention, a fiducial mark is formed of copper foil. In addition, the shape of the fiducial mark is preferably circular in order that it is recognized easily and the occupied area is reduced to a minimum.

15 An apparatus for recognizing the position of a circuit board according to the present invention achieving the above second object includes image pickup means for picking up the image of the surface of a circuit board having a circuit pattern formed on the surface,  
20 recognition means for recognizing the surface of the circuit board from the image provided from the image pickup means, and infrared rays irradiating means for irradiating infrared rays toward the circuit board.

25 According to the apparatus, infrared rays transmit a solder resist film, so that even if the fiducial mark or

the circuit pattern is coated with a solder resist film, it is possible to pick up the image of the fiducial mark with the image pickup means to provide an image with a fine contrast including the fiducial mark.

5        According to a preferable embodiment of an apparatus for recognizing the position of a circuit board of the present invention, a fiducial mark coated with a solder resist film is formed on the surface of the circuit board. The position of the circuit board is recognized by  
10      recognition means on the basis of the position of the fiducial mark recognized from an image provided from image pickup means.

According to another aspect of an apparatus for recognizing the position of a circuit board of the present  
15      invention, the position of the circuit board is recognized on the basis of an image of a circuit pattern coated with a solder resist film. In the case of this apparatus, means for recognizing a predetermined position by holding in advance a reference image corresponding to the pattern  
20      of a predetermined position in the circuit pattern and looking for a part where the correlation between the circuit pattern and the reference image is the highest can be applied to recognition means.

The foregoing and other objects, features, aspects  
25      and advantages of the present invention will become more

apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig. 1A is a plan view illustrating a part of a conventional circuit board, and Fig. 1B is a sectional view taken along line I-I in Fig. 1A.

10 Fig. 2A is a plan view illustrating a part of a conventional circuit board not including a fiducial mark, and Fig. 2B is a sectional view taken along line II-II in Fig. 2A.

15 Fig. 3A is a plan view illustrating a part of a conventional circuit board including a fiducial mark on which solder plating is carried out, and Fig. 3B is a sectional view taken along line III-III in Fig. 3A.

Fig. 4 is a plan view illustrating a part of a conventional circuit board including fiducial marks provided corresponding to the position of an IC device.

20 Fig. 5A is a plan view illustrating a part of a circuit board having a fiducial mark according to an embodiment of the present invention, and Fig. 5B is a sectional view taken along line V-V in Fig. 5A.

25 Fig. 6 is a view illustrating a structure of an apparatus for recognizing the position of a circuit board according to an embodiment of the present invention.

Fig. 7 is a block diagram illustrating an example of a structure of an image processing apparatus.

Fig. 8 is a diagram illustrating an example of an image of a fiducial mark.

5 Fig. 9 is a view illustrating a structure of an apparatus for recognizing the position of a circuit board according to another embodiment of the present invention

Fig. 10 is a plan view illustrating an example of a recognized circuit pattern.

10 Fig. 11 is a view illustrating a reference image in a region A illustrated in Fig. 10.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be described in the following with reference to the drawings.

15 Fig. 5A is a plan view illustrating a fiducial mark in a circuit board and its periphery according to an embodiment of the present invention, and Fig. 5B is a sectional view taken along line V-V in Fig. 5A.

Referring to Figs. 5A, 5B, a circular fiducial mark 2 formed using copper foil, the same material as a circuit pattern, and a solder resist film 3 are formed on a main surface of a board 1 formed of glass epoxy which is to be the base of a circuit board. As illustrated in Fig. 5B, fiducial mark 2 is coated with solder resist film 3 and 25 not exposed, so that the surface of fiducial mark 2 is

always kept stable without being oxidized or having solder attached thereto.

Fig. 6 illustrates a structure of an apparatus for recognizing the position of a circuit board according to 5 an embodiment of the present invention. This apparatus includes, for example, a LED (infrared rays irradiating means) 21 for emitting infrared rays toward a circuit board 20 which is the same as the circuit board illustrated in Figs. 5A, 5B, a CCD (Charge Coupled Device) 10 camera (image pickup means) 22 for picking up the image of the surface of circuit board 20, and an image processing apparatus 23 inputting the image of the surface of circuit board 20 from CCD camera 22 for recognizing the position of fiducial mark 2. Position data 24 indicating the 15 recognized position is provided from image processing apparatus 23.

Now, operation of the apparatus for recognizing the position of a circuit board illustrated in Fig. 6 will be described. Fiducial mark 2 is coated with solder resist film 3, and solder resist film 3 generally presents deep green. Therefore, although it is hard for light in the 20 visible region to transmit solder resist film 3, it presents almost transparent characteristics with respect to infrared rays. In addition, a CCD element often used 25 as an image pickup element in a television camera has high

sensitivity for the infrared rays region. Accordingly, if infrared rays are irradiated toward fiducial mark 2 and the image of fiducial mark 2 is picked up by CCD camera 22, an image with a fine contrast including fiducial mark 2 is provided from CCD camera 22 in the case where solder resist film 3 is coated as well as in the case where it is not coated.

An approximate position of circuit board 20 is mechanically determined by a fiducial hole and a fiducial pin (not shown), and CCD camera 21 is set so that fiducial mark 2 comes into the visual field of CCD camera 22. Then, the image of a part of circuit board 20 including fiducial mark 2 is picked up by CCD camera 22. The image including fiducial mark 2 is provided from CCD camera 22 to image processing apparatus 23.

Image processing apparatus 23 may be a conventionally used one, and constituted as illustrated in Fig. 7, for example. The image provided from CCD camera 22 has noise removed in a preprocessing block 31 and is converted into a binary image, specifically, a picture element having lightness higher than a predetermined threshold value is made "1", and a picture element darker than it is made "0". Then, the binary picture is set in a memory 32. Fig. 8 is a diagram illustrating an example of an image set in memory 32 in which picture elements as hatched

indicate picture elements of "1". In this case, if fiducial mark 2 presents lighter picture elements, the hatched part in Fig. 8 indicates fiducial mark 2. An object recognizing block 33 recognizes fiducial mark 2  
5 from the image in memory 32. A position recognizing block 34 determines the position of fiducial mark 2 recognized by object recognizing block 33 by calculating the center of gravity of an object, for example. The determined position is provided as position data 24.

10 According to the above embodiment, a fiducial mark 2 of the same material as a circuit pattern is formed together with the circuit pattern on the main surface of board 1, and fiducial mark 2 is coated with solder resist film 3 in circuit board 20 to constitute circuit board 20,  
15 so that there is an effect that the surface of fiducial mark 2 is always kept in a stable state without being oxidized or having solder attached thereto.

In addition, infrared rays irradiating means 21 for irradiating infrared rays toward fiducial mark 2 formed on  
20 the main surface of board 1 is provided in an apparatus for recognizing the position of a circuit board, so that it is possible to obtain an image with a fine contrast in the case where fiducial mark 2 is coated with solder resist film 3 as well as in the case where it is not  
25 coated. As a result, there is an effect that it is

possible to certainly recognize the position of circuit board 20 having fiducial mark 2 coated with solder resist film 3 in addition to the position of a circuit board having fiducial mark 2 not coated with solder resist film

5 3.

Fig. 9 illustrates a structure of an apparatus for recognizing the position of a circuit board according to another embodiment of the present invention. Fig. 10 illustrates an example of a part of a circuit board 20a having no fiducial mark 2 used in this embodiment. A circuit pattern 4 having a larger width of is a part where a lead wire of an IC is soldered, and it is not coated with solder resist film 3. The one having a smaller width is a circuit pattern 4 having a line width of 0.1mm, and it is coated with solder resist film 3.

Now, operation will be described. An approximate position of circuit board 20a is mechanically determined by a fiducial hole and a fiducial pin (now shown). A CCD camera 22 is set so that the part of circuit board 20a illustrated in Fig. 10 comes into the visual field of CCD camera 22. Then, the image of the part illustrated in Fig. 10 is picked up by CCD camera 22. An image including the part illustrated in Fig. 10 is provided from CCD camera 22 to an image processing apparatus 23.

25 Solder resist film 3 coating circuit pattern 4 has

almost no effect on an image with respect to infrared rays received from LED 21. Accordingly, all circuit patterns 4 come to exist in the image as lighter parts with a fine contrast. Image processing apparatus 23 functions as the 5 one illustrated in Fig. 6 and provides position data. Specifically, circuit pattern 4 is recognized from an image set in a memory 32 in an object recognizing block 33, and the position of circuit pattern 4 required for recognizing the position of circuit board 20a (for 10 example, the pattern in region A) is determined in a position recognizing block 34. Object recognizing block 34 can employ template matching in which a reference image as illustrated in Fig. 11 is held in advance, and a part having the highest correlation with the reference image is 15 looked for on the occasion of recognizing region A.

According to the above embodiment, infrared rays irradiating means 21 for irradiating infrared rays toward the circuit pattern formed on the main surface of board 1, is provided, so that there are effects that an image 20 having a fine contrast can be obtained in respect to the circuit pattern coated with solder resist film 3, fiducial marks for respective ICs which are required to have high attachment precision become unnecessary, and it is possible to miniaturize circuit board 20a.

25 Although the present invention has been described and

illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of  
5 the appended claims.

WHAT IS CLAIMED IS:

1. A circuit board, comprising:
  - a board (1);
  - a circuit pattern formed on a main surface of said board (1);
  - 5 a fiducial mark (2) formed of the same material as that of said circuit pattern on the main surface of said board (1); and
  - a solder resist film (3) formed to cover said fiducial mark (2).
2. The circuit board according to claim 1, wherein said fiducial mark (2) is formed of copper foil.
3. The circuit board according to claim 1, wherein said fiducial mark (2) is circular.
4. An apparatus for recognizing the position of a circuit board, comprising:
  - image pickup means (22) for picking up the image of the surface of a circuit board (20, 20a) having a circuit pattern formed on the surface;
  - 5 recognition means (23) for recognizing the position of said circuit board (20, 20a) from the image provided

from said image pickup means (22); and  
infrared rays irradiating means (21) for irradiating  
10 infrared rays toward said circuit board (20, 20a).

5. The apparatus for recognizing the position of a circuit board according to claim 4, wherein said infrared rays irradiating means (21) includes a LED (21) for irradiating infrared rays.

6. The apparatus for recognizing the position of a circuit board according to claim 4, wherein said image pickup means (22) includes a CCD camera.

7. The apparatus for recognizing the position of circuit board according to claim 4, wherein  
5 a fiducial mark (2) coated with a solder resist film (3) is formed on the surface of said circuit board (20), and wherein

said recognition means (23) recognizes the position of said circuit board (20) on the basis of the position of said fiducial mark (2) recognized from the image provided from said image pickup means (22).

8. The apparatus for recognizing the position of a circuit board according to claim 7, wherein said fiducial

mark (2) is formed of the same material as that of said circuit pattern.

9. The apparatus for recognizing the position of a circuit board according to claim 8, wherein said circuit pattern and said fiducial mark (2) are formed of copper foil.

10. The apparatus for recognizing the position of a circuit board according to claim 7, wherein said fiducial mark (2) is circular.

11. The apparatus for recognizing the position of a circuit board according to claim 4, wherein

the circuit pattern on the surface of said circuit board (20a) is coated with a solder resist film (3), and  
5 wherein

said recognition means (23) includes means for recognizing the position of said circuit board (20a) on the basis of the image of said circuit pattern provided from said image pickup means (22).

12. The apparatus for recognizing the position of a circuit board according to claim 4, wherein

said recognition means (23) includes an image

processing apparatus (23), including;

5           a preprocessing block (31) for removing noise in  
the image signal provided from said image pickup means  
(22), making the image signal binary, and the like,

a memory (32) for storing the image signal which  
has been made binary,

10           an object recognizing block (33) for recognizing  
a particular object from the image signal stored in said  
memory (32), and

15           a position recognizing block (34) for recognizing the  
position of said circuit board (20, 20a) from the position  
of the object recognized by said object recognizing block  
(33).

13. The apparatus for recognizing the position of a  
circuit board according to claim 11, wherein said  
recognition means (23) includes means for recognizing a  
predetermined position by holding a reference image for  
5           recognizing said predetermined position of said circuit  
board (20a) and looking for a part having the highest  
correlation with said reference image out of the image of  
said circuit pattern.

14. Use of infra-red radiation to assist detection and recognition of a fiducial mark on the surface of a circuit board, which mark is covered by a solder resist film.

5

15. A circuit board constructed, adapted and arranged to operate substantially as described hereinbefore with reference to and as shown in figures 5A and 5B of the drawings.

10

16. An apparatus for recognising the position of a circuit board, which apparatus is constructed, adapted and arranged to operate substantially as described hereinbefore with reference to and as shown  
15 in figures 6 to 11 of the drawings.

Patents Act 1977

Examiner's report to the Comptroller under  
Section 17 (The Search Report)

Application number

9123003.7

## Relevant Technical fields

(i) UK CI (Edition K ) H1R (RAA,RAC,RAV,RBX);  
H1K (KRM)

(ii) Int CI (Edition 5 ) H05K 13/00

## Search Examiner

R C HRADSKY

## Databases (see over)

(i) UK Patent Office

(ii) WPI ONLINE

## Date of Search

20 JANUARY 1992

## Documents considered relevant following a search in respect of claims

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2231953 A (DYNAPERT) whole document	1

SF2(p)

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Category	Identity of document and relevant passages -24-	Relevant to claim(s)

### Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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